

State of California  
Department of Fish and Wildlife

# Memorandum

**Date: 24 August 2021**

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North Central Region Fisheries

From: Isaac Chellman, Environmental Scientist;  
High Mountain Lakes;  
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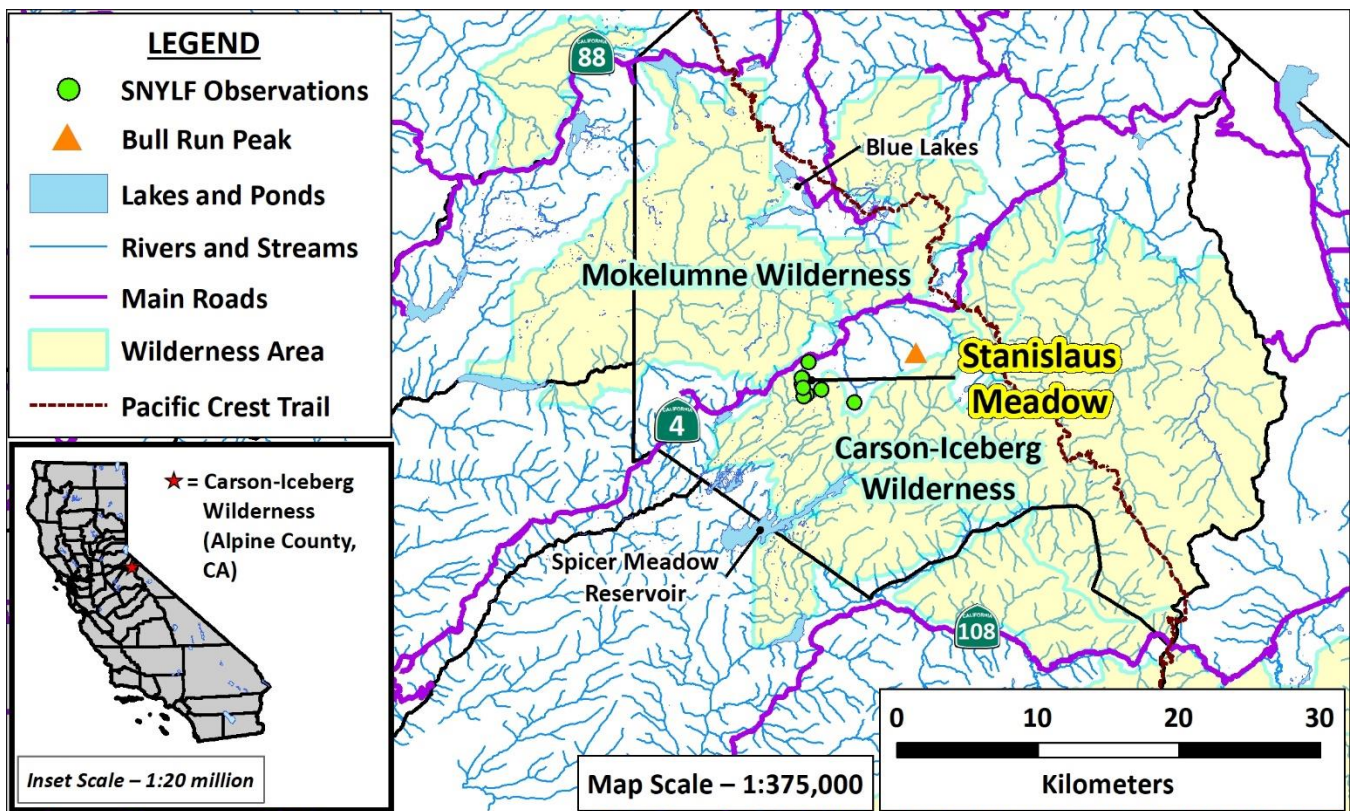
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**Subject: Native amphibian monitoring in Alpine County: 2020 surveys in the North Fork Stanislaus River watershed**

## SUMMARY

This memorandum includes results from surveys in the headwaters of the North Fork Stanislaus River (NFSR), located in Alpine County (**Figure 1**). The headwaters, in particular Stanislaus Meadow, contain a known population of state threatened Sierra Nevada Yellow-legged Frog (*Rana sierrae*, SNYLF), which California Department of Fish and Wildlife (CDFW) staff monitor consistently. Before 2020, the most recent survey of the area by CDFW occurred in August 2016, during which staff surveyed Stanislaus Meadow. Although there have been occasional observations of a single SNYLF adult in Pacific Creek (approximately 3 kilometers [km] east of Stanislaus Meadow), the next closest location with known SNYLF presence is a small population located in the Wheeler Lake drainage, approximately 4.5 km northwest of Stanislaus Meadow. In August 2020, a CDFW biologist revisited the NFSR drainage to conduct a visual encounter survey (VES) for SNYLF. Surveys in 2020 included all of the NFSR headwaters that still contained surface water (from upstream of Stanislaus Meadow, through the meadow, and downstream to approximately 200 meters [m] past the confluence of the Bull Run Lake and Heiser Lake outlet streams), a portion of the Bull Run Lake and Heiser Lake outlet streams, and an unnamed pond west of Heiser Lake. During the survey, CDFW observed SNYLF in nearly all wetted habitats. Most SNYLF, including nearly all tadpoles, were located in Stanislaus Meadow, or the stretch of the NFSR upstream of Stanislaus Meadow that still contained surface water. However, areas with surface water downstream of Stanislaus Meadow, and sections of the Heiser Lake outlet and Bull Run Lake outlet also contained low densities of post-metamorphic SNYLF.

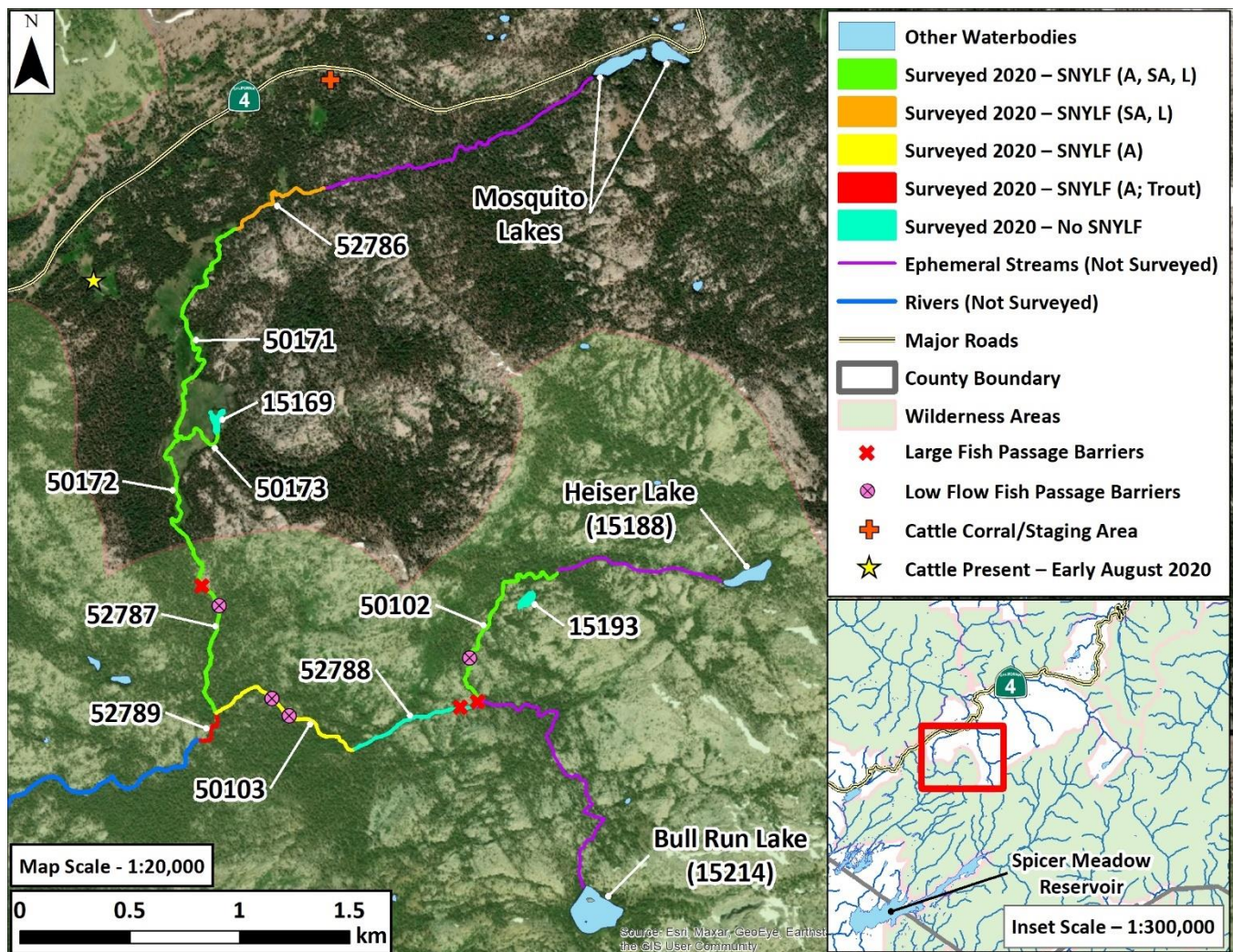


**Figure 1.** Alpine County, CA. Green dots show *Rana sierrae* (SNYLF) sites with positive detections by California Department of Fish and Wildlife staff during recent visual encounter surveys in the area of the North Fork Stanislaus River headwaters.

## ENVIRONMENTAL SETTING

The NFSR headwaters, including Stanislaus Meadow and the surrounding area (**Figure 2**), is located south of State Route (SR) 4 in southwest Alpine County. Stanislaus Meadow is located outside the northern boundary of Carson-Iceberg Wilderness and cattle grazing is permitted in the area surrounding Stanislaus Meadow. However, other locations covered in this memorandum, include the NFSR drainage downstream of Stanislaus Meadow, are located within designated wilderness (**Figure 2**). The NFSR originates from Mosquito Lakes and several small, unnamed tributaries, including the outlets of Heiser Lake and Bull Run Lake, which are located east of Stanislaus Meadow. Elevations in the area range from 9,495 feet (ft; 2,894 m) at Bull Run Peak, down to 7,420 ft (2,262 m) at the downstream end of the surveyed portion of NFSR. Stanislaus National Forest (SNF) manages Stanislaus Meadow and the surrounding land. An unmaintained four-wheel-drive (4x4) dirt road connects SR 4 with the Carson-Iceberg wilderness boundary, but most visitors park at the official Stanislaus Meadow trailhead, which is located adjacent to the south side of SR 4. The hiking trail begins at the wilderness boundary and proceeds along the western slope above the NFSR. This small trail system connects Stanislaus Meadow with Heiser Lake, Bull Run Lake, and Mosquito Lakes.





**Figure 2.** Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) and trout occupancy in the North Fork Stanislaus River (NFSR) headwaters, Alpine County, CA. Since the mid-1990's, California Department of Fish and Wildlife (CDFW) and Stanislaus National Forest (SNF) staff have consistently observed a small SNYLF population in Stanislaus Meadow. In 2020, CDFW survey efforts included a larger portion of the NFSR than typically surveyed, from approximately 500 m upstream of Stanislaus Meadow, to approximately 1 kilometer below Stanislaus Meadow (downstream end of Site ID 52789), and up the Bull Run/Heiser Lake outlet stream to the upstream end of Site ID 50102. CDFW field staff first observed trout at Site ID 52789 during visual encounter surveys (VES) in 2020. Observed SNYLF life stages are denoted by letter codes in the legend: "A" = adults, "SA" = subadults, and "L" = larvae. All flowing waters in the area surveyed by CDFW drain into Union Reservoir. Displayed five-digit numbers are Site IDs, which CDFW uses to partition waterbodies for data collection. CDFW added Site IDs 52786–52789 in 2020. Additionally, CDFW updated all existing GIS polygons for the NFSR area to more accurately reflect the composition of the depicted waterbodies.

## THREATS

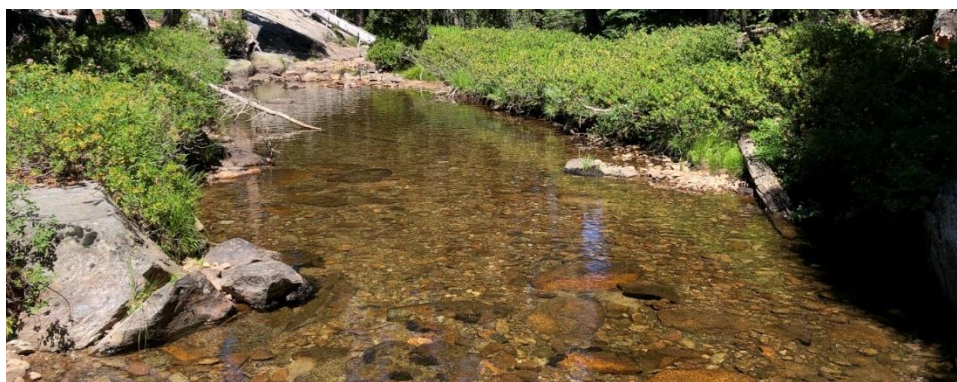
### ***Marginal Habitats***

SNYLF are persisting at relatively low density throughout a large extent of the NFSR drainage (**Figure 2**). Occupied habitat includes mostly ephemeral stream channel with small, shallow, intermittent pools. Any disturbance, natural or otherwise, that results in changes to the hydrology or limnology of the habitat poses a potential extirpation risk to the population. Potential risks include severe winter conditions, extended drought, or anthropogenic habitat disturbances.

### ***Introduced Fish***

Fish have not been observed in Stanislaus Meadow. However, CDFW stocks catchable triploid Rainbow Trout (*Oncorhynchus mykiss*; RT; CDFW 2015) into Mosquito Lakes, which are two popular recreational lakes on SR 4. Generally, the Mosquito Lakes drain northeast—away from Stanislaus Meadow—but during high water years, the lakes may drain southwest and introduce trout into the ephemeral stream connecting Stanislaus Meadow and Mosquito Lakes. Data suggest that fish are unable to reach the sections of Stanislaus Meadow consistently occupied by frogs. For example, CDFW and USFS staff have not observed any fish in Stanislaus Meadow during numerous VES between 2005 and 2020.

During surveys in August 2020, CDFW observed 21 trout in large, shallow pools in the NFSR downstream of Stanislaus Meadow (**Figure 3**). The areas in which staff observed trout were approximately 1 km downstream of the meadow and about 50 m downstream of the NFSR confluence with the Bull Run Lake/Heiser Lake Outlet (i.e., staff observed trout in Site ID 52789; **Figures 2 and 3**). There is a large barrier to upstream fish passage on the NFSR between Stanislaus Meadow and the fish-bearing areas observed by CDFW in 2020 (**Figure 2**; also see **Figure A1** in the [APPENDIX](#)). Additionally, there are several small barriers and one large barrier to upstream fish passage along the Bull Run Lake/Heiser Lake Outlet (Site IDs 52788 and 50102; **Figure 2**). Therefore, fish from the lower NFSR are not able to reach the SNYLF-containing habitats upstream.



**Figure 3.** Large, shallow pool on the North Fork Stanislaus River (Site ID 52789), downstream of the confluence with the Bull Run Lake/Heiser Lake outlet stream, in which California Department of Fish and Wildlife staff observed trout in August 2020. (CDFW)



Bull Run Lake contains a self-sustaining population of Brook Trout (*Salvelinus fontinalis*; BK). CDFW stocked Bull Run Lake with BK until 2000, after which aerial stocking ceased. CDFW conducted the most recent fish survey of Bull Run Lake in 2014, during which staff caught 12 adult BK during an overnight gill net set. Additionally, numerous recent anecdotal observations from hikers and anglers posted online (e.g., AllTrails.com reviews) report fish jumping in the lake. BK may occasionally enter SNYLF-occupied habitat downstream by exiting Bull Run Lake during higher flows. However, any BK that may emigrate from Bull Run Lake would be prevented from accessing Site ID 50102 or Stanislaus Meadow through a combination of barriers and stream channels that often dry completely. Until 2000, CDFW also stocked Heiser Lake annually with an allotment of BK. CDFW staff have not sampled Heiser Lake for fish since 2004, during which staff caught zero trout during an overnight gill net set. Therefore, BK may have died out from Heiser Lake in the absence of stocking.

During VES in late summer 2020, CDFW field staff did not observe trout in any of the surveyed reaches upstream of Site ID 52789; **Figure 2**). However, portions of Site ID 50103 still contained flowing water and intermittent pools, so fish may be present, having potential access to the lower end of the Bull Run Lake/Heiser Lake outlets during higher water. Other locations CDFW surveyed in 2020, including Site IDs 52787 and 52788 were almost completely dry, and staff observed no fish.

### ***Over-Snow Vehicle Use***

SNYLF may be threatened by direct impacts from over-snow vehicle (OSV) use in Stanislaus Meadow, particularly during the early spring, while emerging from overwintering (USFS 2019a). Additionally, OSV have potential to affect SNYLF via snow and soil compaction, noise disturbance, and fuel/oil leaks (USFS 2019a, USFWS 2020). These potential threats are mitigated by the recent finalization of the Stanislaus National Forest OSV Use Designation Final Environmental Impact Statement, which designates a minimum depth of 24 inches of snow for OSV use in Stanislaus Meadow (USFS 2019b).

### ***Cattle Grazing***

Studies investigating direct interactions between cattle and SNYLF populations have not been conducted. However, the U.S. Forest Service acknowledges cattle effects to aquatic resources in the Mokelumne Wilderness Management Guidelines (USFS 1995). Additionally, potential negative effects of livestock grazing on SNYLF habitat are discussed in the U.S. Fish and Wildlife Service (USFWS) final rule for listing SNYLF as a federally endangered species (USFWS 2014, pg. 24628–24630). USFWS concluded: “*Current livestock grazing activities may present an ongoing, localized threat to individual populations in locations where the populations occur in stream riparian zones and in small waters within meadow systems, where active grazing co-occurs with extant frog populations.*” The USFWS concluded that livestock grazing that complies with USFS grazing guidelines is not expected to negatively affect most SNYLF populations (USFWS 2014).

Cattle are often present in the NFSR area (**Figure 4**) and there is an established grazing allotment that includes the entire NFSR area discussed in this memorandum. In August 2020, CDFW field

staff observed a cattle herd in an unnamed meadow northwest of Stanislaus Meadow (**Figure 2**), and there was abundant evidence of cattle use throughout the area, including tracks and manure. The small meadow northwest of the main Stanislaus Meadow (**Figure 2**, yellow star) appeared heavily impacted by cattle use, including deeply incised channels. During surveys in early August 2020, there was a cattle exclusion fence surrounding the main Stanislaus Meadow, which appeared to be effectively preventing cattle from accessing Site IDs 50171, 50172, 50173, and 15169. Despite the presence of fencing, there was clear evidence of cattle having accessed the meadow in the past. SNF staff informed CDFW that cattle are provided access to Stanislaus Meadow during a relatively brief period (i.e., a few weeks) in the fall (SNF, pers. comm.). This low duration, high intensity cattle access creates the potential for negative effects to SNYLF from cattle using aquatic habitat occupied by SNYLF, particularly at a time of year when water may be limited, thus concentrating both cattle and SNYLF into the same areas.



**Figure 4.** Cattle grazing next to the Stanislaus Meadow parking lot on 5 August 2020. (CDFW)

### ***Disease***

Chytrid fungus (*Batrachochytrium dendrobatidis*; *Bd*) is present in all SNYLF populations in the northern Sierra Nevada that CDFW has sampled. In 2008 and 2010, field staff collected 20 epithelial swabs from SNYLF captured in Stanislaus Meadow (Site IDs 50171, 50172, and 50173). Partner scientists screened the swabs for presence of *Bd* DNA using real-time quantitative polymerase chain reaction (qPCR) analysis. The swab analyses detected very light to heavy infection intensity. In 2020, CDFW collected an additional nine epithelial swabs from Stanislaus Meadow (n = 6) and the NFSR approximately 200 m downstream of Stanislaus Meadow (n = 3). In fall 2020, partner scientists at the Sierra Nevada Aquatic Research Laboratory (SNARL) screened the new swabs for presence of *Bd* DNA using real-time qPCR analysis (Knapp and

Lindauer 2020). The swab analyses detected either no *Bd* (for Stanislaus Meadow, n = 2; for NFSR, n = 1), or very light to high intensity. Only one sample from NFSR, collected from a subadult SNYLF, resulted in *Bd* loads that may be high enough to indicate potential for the sampled frog to experience mortality from chytridiomycosis (the disease caused by *Bd*). No swabs collected from adult SNYLF in the NFSR area in 2020 had high *Bd* loads.

### ***Loss of Genetic Diversity***

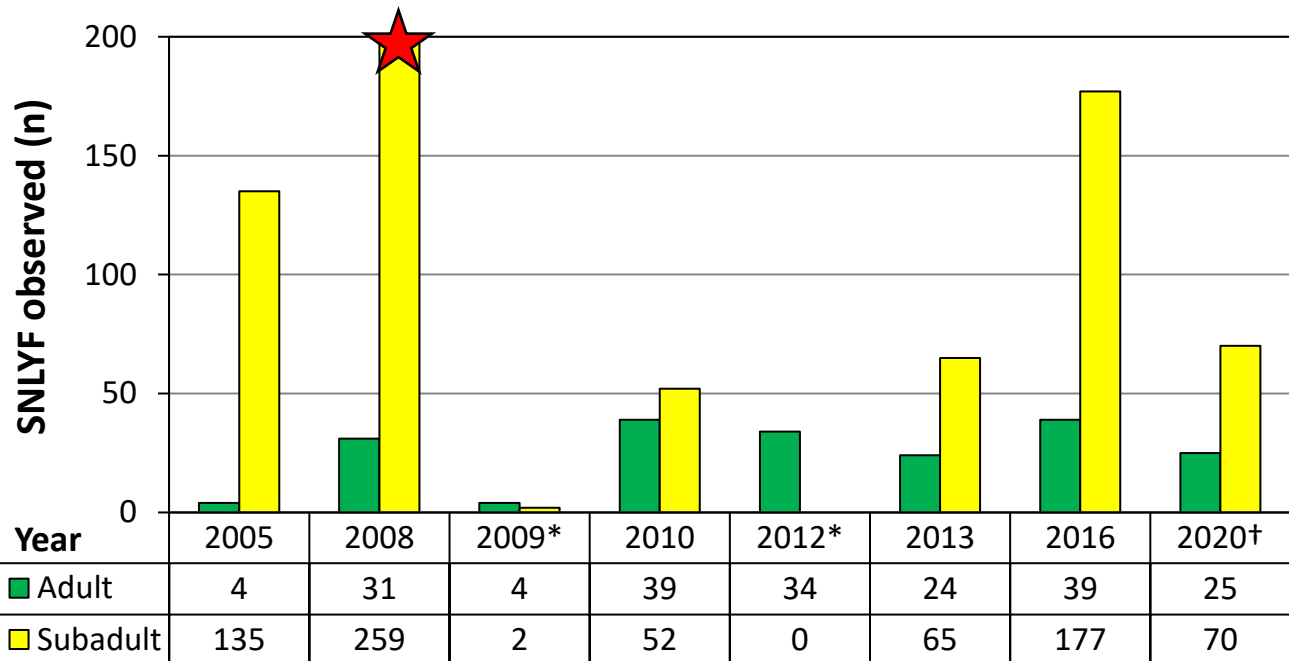
Like many SNYLF populations in the northern Sierra Nevada, the populations in the NFSR area are relatively small when compared with many historic and/or *Bd*-naïve SNYLF populations. In fact, most SNYLF populations in Alpine County are small and isolated from one another. The nearest known SNYLF population with more widespread occupancy is located in the Jeff Davis Creek area (CDFW 2014), approximately 12 km north. In addition to the threats presented by stochastic environmental events (e.g., drought, wildfire, or especially harsh winter) when a population is geographically isolated, genetic isolation can lead to factors such as inbreeding depression, genetic drift, fixation of deleterious alleles, and loss of genetic diversity, all of which are population genetic factors exacerbated in small populations (Frankham et al. 2009).

### **METHODS and RESULTS**

CDFW used standard VES (CDFW, unpubl. High Mountain Lakes survey protocol), modified from methods developed by Fellers and Freel (1995), to survey for aquatic species in the NFSR area. CDFW focused on surveying for amphibians, particularly SNYLF. However, CDFW staff also noted other amphibians, reptiles, and trout observed during VES. Due to ample cover (e.g., undercut banks, submerged logs, and overhanging vegetation), pool staining, shade, and speed of trout, CDFW staff were not able to accurately identify species of trout seen in the lower stream reach (Site ID 52789; **Figures 2 and 3**).

During all survey years, CDFW staff have observed a large majority of SNYLF in the primary stream channel flowing through Stanislaus Meadow (Site IDs 50171, 50172, and 50173; **Figure 2**). Adding together detections from all surveys of the NFSR area (2005–2020), 90% of adults, 95% of subadults, and 96% of tadpoles have been observed in Stanislaus Meadow. Given the wider survey area included during VES in 2020, Stanislaus Meadow did not account for as large a percentage of post-metamorphic SNYLF that staff observed (72% and 73% of adults and subadults, respectively). However, staff detected 90% of SNYLF larvae in Stanislaus Meadow during surveys in 2020.

Relative abundance of adult SNYLF detected during VES has remained relatively consistent over time (**Figure 5**). Subadult observations have been highly variable (**Figure 5**). However, subadult detections are highly dependent on survey timing, where more individuals tend to be detected later in the summer and early fall (depending on conditions), when the latest late stage tadpole cohorts tend to metamorphose (pers. obs.). Detections of larval SNYLF have generally increased during the survey period summarized in this memorandum (**Figure 6**).



**Figure 5.** Number of adult and subadult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNLYF) detected during visual encounter surveys (VES) in the North Fork Stanislaus River area (NFSR) between 2005 and 2020. California Department of Fish and Wildlife (CDFW) staff have observed most SNLYF in Stanislaus Meadow (Site IDs 50171, 50172, and 50173). Field staff have also detected SNLYF in pooled areas of NFSR (Site IDs 52786 and 52787) and the Heiser Lake/Bull Run Lake outlet streams (Site IDs 50102 and 50103). CDFW staff have occasionally detected SNLYF in a small pond east of the Heiser Lake outlet (Site ID 15193), but staff did not detect SNLYF there in 2020. CDFW also visited the NFSR area for more limited surveys in 2004 and 2015. However, in both years, staff did not survey all of Stanislaus Meadow, so the results are not comparable with the years displayed, during which staff visited all core sites in Stanislaus Meadow (Site IDs 50171, 50172, and 50173).

Survey effort for NFSR locations outside of Stanislaus Meadow varied over time. CDFW staff did not survey the following sites during the years listed:

15169: 2005–2013

15193: 2009 and 2016

50102: 2009 and 2016

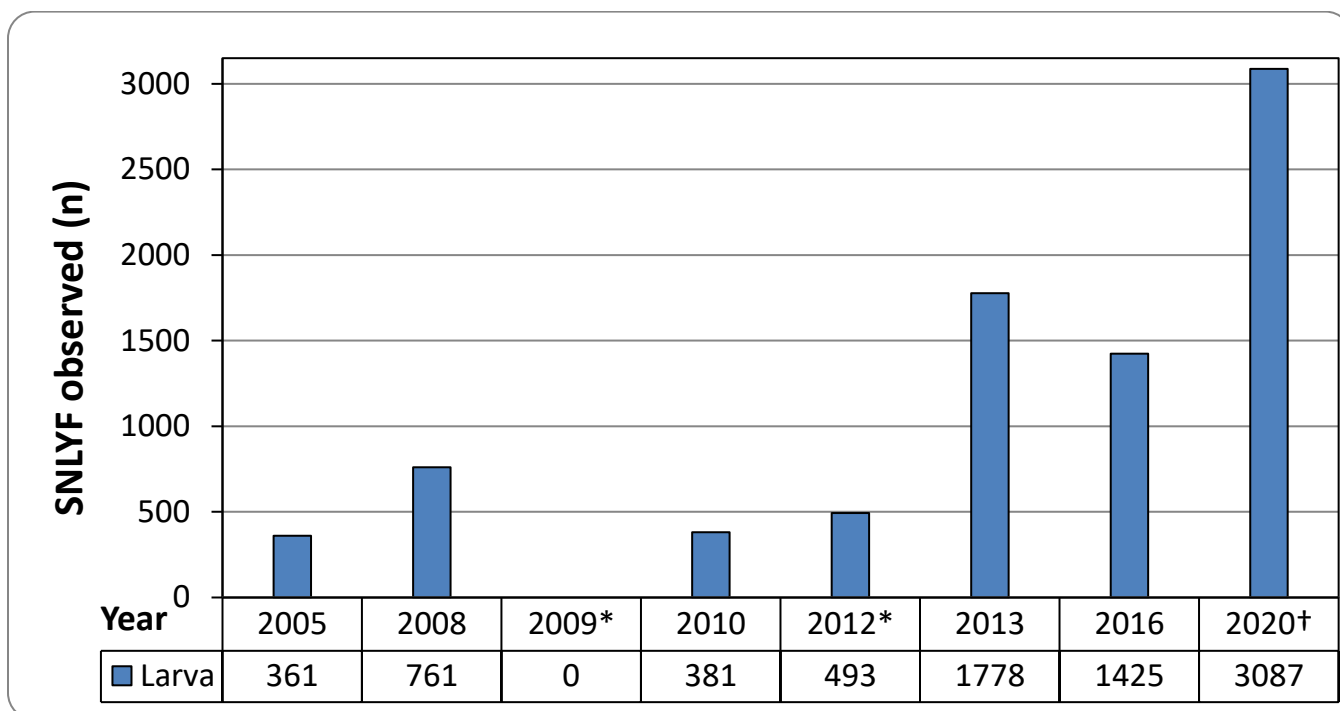
50103: 2005, 2009–2013, 2016

\*In 2009 and 2012, CDFW surveyed Stanislaus Meadow much earlier in the year (late May and mid-June, respectively) when compared with surveys during the other years displayed. Early season surveys may partly account for the low number of detections during these years.

†In 2020, CDFW added several survey polygons to NFSR (see **Figure 2**) and surveyed larger portions of the stream reaches than previous years. New survey reaches included Site IDs 52786–52789. Additionally, CDFW staff surveyed larger portions of Site IDs 50102 and 50103 than previously included in past surveys.

★ [Red star] Indicates a subadult count above the scale range of the histogram (n = 259).





**Figure 6.** Number of larval Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNLYF) detected during visual encounter surveys (VES) in the North Fork Stanislaus River area (NFSR) between 2005 and 2020. California Department of Fish and Wildlife (CDFW) staff have observed most SNLYF in Stanislaus Meadow (Site IDs 50171, 50172, and 50173). Field staff have also detected SNLYF in pooled areas of NFSR (Site IDs 52786 and 52787) and the Heiser Lake/Bull Run Lake outlet streams (Site IDs 50102 and 50103). CDFW staff have occasionally detected SNLYF in a small pond east of the Heiser Lake outlet (Site ID 15193), but staff did not detect SNLYF there in 2020. CDFW also visited the NFSR area for more limited surveys in 2004 and 2015. However, in both years, staff did not survey all of Stanislaus Meadow, so the results are not comparable with the years displayed, during which staff visited all core sites in Stanislaus Meadow (Site IDs 50171, 50172, and 50173).

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\*In 2009 and 2012, CDFW surveyed Stanislaus Meadow much earlier in the year (late May and mid-June, respectively) when compared with surveys during the other years displayed. Early season surveys may partly account for the low number of detections during these years, particularly the complete lack of larval SNLYF detections in 2009.

†In 2020, CDFW added several survey polygons to NFSR (see **Figure 2**) and surveyed larger portions of the stream reaches than previous years. New survey reaches included Site IDs 52786–52789. Additionally, CDFW staff surveyed larger portions of Site IDs 50102 and 50103 than previously included in past surveys.

Two exceptions to the trends listed above were 2009, during which staff detected very few SNYLF of any life stage, and 2012, during which staff detected no subadults. In both 2009 and 2012, staff surveyed Stanislaus Meadow earlier in the spring (late May and mid-June, respectively) whereas staff surveyed the NFSR area in summer during the other survey years. For example, surveys in 2008, 2010, 2013, 2016, and 2020 occurred in August. In 2005, another year with low adult and larval SNYLF detections, staff surveyed Stanislaus Meadow during the second week of September.

Given the larger survey area covered by CDFW in 2020, staff took numerous site photos to document the area. **Figures 7–26** provide examples of key habitat features in the various locations staff surveyed. Photos are generally organized north to south along the NFSR, and west to east along the Bull Run Lake/Heiser Lake outlet. The [APPENDIX](#) provides additional images of fish passage barriers and cattle fencing that staff observed at the upstream and downstream ends of Stanislaus Meadow. Readers may use the following link to skip directly to the [DISCUSSION section](#).



**Figure 7.** The upstream end of Site ID 52786, which is located approximately 500 meters (m) upstream of Stanislaus Meadow, in August 2020, looking northeast. Surface flow was absent from approximately 100 m downstream of this location to the survey end point. (CDFW)





**Figure 8.** The North Fork Stanislaus River (Site ID 52786), where the river flows through a small meadow upstream of Stanislaus Meadow, in August 2020, looking north. (CDFW)



**Figure 9.** The upstream end of Site ID 50171 (north end of Stanislaus Meadow) in August 2020, looking north. (CDFW)





**Figure 10.** Site ID 50171 in August 2020, looking upstream. (CDFW)



**Figure 11.** Site ID 50171 in August 2020, looking upstream. This photo was taken close to where several ephemeral tributaries flowing from a meadow to the west (in which CDFW staff observed cattle in August 2020; yellow star in **Figure 2**) enter the main stem North Fork Stanislaus River. (CDFW)





**Figure 12.** Downstream end of Site ID 50171 in August 2020, looking south. The downstream portion of this site is located in the middle of Stanislaus Meadow, where less surface water is present when compared with the northern and southern ends of the meadow. (CDFW)



**Figure 13.** Upstream end of Site ID 50172 in August 2020, looking north. (CDFW)





**Figure 14.** A dry section of Site ID 50173. During surveys in early August 2020, this site only contained surface water within the first 100 meters of the main stem North Fork Stanislaus River.



**Figure 15.** Site ID 15169 in August 2020, looking north. (CDFW)





**Figure 16.** An adult female Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Site ID 50172 in August 2020. (CDFW)



**Figure 17.** A large stream pool at the lower end of Site ID 50172 (the downstream end of Stanislaus Meadow) in August 2020, looking south. (CDFW)





**Figure 18.** The upstream end of Site ID 52787 in August 2020, looking south. (CDFW)



**Figure 19.** View from the top of a large barrier to upstream fish movement along Site ID 52787 in August 2020, looking south (CDFW)





**Figure 20.** Site ID 50102 in August 2020, looking east. (CDFW).



**Figure 21.** A shallow pool area near the upstream end of Site ID 50103 in which CDFW staff observed two adult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*) in August 2020. (CDFW)





**Figure 22.** Two still frame captures from a video taken of a Sierra marten (*Martes caurina sierrae*) located along Site ID 52788 on 5 August 2020. Staff observed the marten moving downstream by hopping along boulders in a mostly dry stream channel. (CDFW)



**Figure 23.** Site ID 50102 in August 2020, looking north. (CDFW)





**Figure 24.** An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) resting at the bottom of a pool in Site ID 50102 in August 2020.



**Figure 25.** The upstream end of Site ID 50102. Surface flow was absent from approximately 200 meters downstream of this location to the survey end point.





**Figure 26.** Site ID 15193 in August 2020, looking northeast. (CDFW)

## **DISCUSSION**

Sixteen years of monitoring data suggest the NFSR area SNYLF population has remained relatively stable (albeit at a small population size; **Figure 5**). However, relatively low SNYLF detections make deriving trends difficult. Other important factors may be influencing changes in the number of SNYLF life stages observed between years, including weather conditions on the survey day (i.e., surveys on cooler, windier days tend to result in fewer detections than surveys on warmer, calmer days; pers. obs.), changes in surrounding land use (e.g., cattle grazing intensity and duration), and observer bias (Mazerolle et al. 2007).

Another notable confounding factor is drastic shifts in precipitation and snowpack in the Sierra Nevada during the past decade. These dramatic inter-annual fluctuations increase the difficulty of interpreting population trends. For example, since 2012, winter precipitation in the northern Sierra Nevada has alternated from far below average during an extended drought (2012–early 2016), to record-setting (2016–2017), to well below average (2017–2018), to well above average (2018–2019), and back to far below average in 2019–2020 (CDEC 2021). The winter prior to the surveys discussed in this memorandum was comparable with the driest year (2013–2014) of the 2012–2016 drought (CDEC 2021).

SNYLF mortality can increase during long winters with deep snowpack (Bradford 1983). Contrarily, drought conditions can dry up many areas normally occupied by SNYLF, especially in places like the NFSR area, where much of the available aquatic habitat is small, shallow meadow

pools and ephemeral streams. One of the mitigating factors to exceptionally dry water years is that sections of Stanislaus Meadow appear to hold perennial water. However, there may be long term concerns for SNYLF persistence if the water tables lower, causing these habitats to dry more frequently and over longer durations, particularly with continued trends of warmer annual temperatures, later onset of winter precipitation, earlier onset of spring snowmelt, and precipitation falling more often as rain than snow (Lacan et al. 2008, Wright et al. 2013, Garfin et al. 2014, Ryan et al. 2014).

Finally, an important environmental consideration related to SNYLF detections is the time of year during which staff conduct surveys (i.e., depending on weather conditions, shoulder season surveys of high elevation amphibian habitat—in May into early June, and late September into early October—may lead to poorer detectability when compared with surveys during the core summer period of late June through early September; pers. obs.). Survey timing is likely a significant factor in the low number of detections in 2009, when CDFW surveyed Stanislaus Meadow in late May, during which staff observed very few post-metamorphic SNYLF and no tadpoles. Additionally, CDFW conducted surveys relatively early (mid-June) in 2012, during which staff did not detect any subadults. Survey timing likely played a key role in the observed SNYLF detections during those survey years.

Many years of VES have clearly demonstrated that Stanislaus Meadow provides the best SNYLF habitat in the NFSR area. The main channel—particularly the northern- and southern-most ends of the meadow—includes many large pools in which SNYLF breed. These large and deep pools likely provide the most ideal fishless breeding habitat within areas of NFSR currently occupied by SNYLF. Protecting aquatic habitat in Stanislaus Meadow will be important for long term persistence of SNYLF in the NFSR area.

CDFW will continue to occasionally monitor SNYLF in the NFSR area to assess the population status over time. Long-term monitoring is needed to derive population trends and inform management plans. Given multiple potential threats to this population, including climate change, anthropogenic habitat disturbance, and disease, CDFW may consider future efforts to mark adult SNYLF in the Stanislaus Meadow area with passive integrated transponder (PIT) tags. Over time, marking adult SNYLF in this manner would allow capture-mark-recapture analysis, which can provide a more accurate estimation of population size, especially for a relatively small population (Mazerolle et al. 2007). Over time, these marking efforts may provide CDFW and SNF with a better idea of the true SNYLF population size in the NFSR area.

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## APPENDIX

Photographs of barriers to upstream fish passage and cattle fencing in the NFSR area.



**Figure A1.** The upstream portion of a large barrier to upstream fish passage located at UTM 11S 244020 E, 4264728 N, along Site ID 50172. (CDFW)





**Figure A2.** A barrier to upstream fish passage located at UTM 11S 244095 E, 4264634 N, along Site ID 50172 (approximately 100 meters downstream of the barrier shown in **Figure A1**). (CDFW)





**Figure A3.** A small, low flow (i.e., occasional) barrier to upstream fish passage located at UTM 11S 244323 E, 4264205 N, along Site ID 50103. (CDFW)





**Figure A4.** A small, low flow (i.e., occasional) barrier to upstream fish passage located at UTM 11S 244399 E, 4264123 N, along Site ID 50103 (approximately 100 meters upstream of the barrier shown in **Figure A3**). (CDFW)





**Figure A5.** A large barrier to upstream fish passage located at UTM 11S 245181 E, 4264137 N, at the upstream end of Site ID 52788. (CDFW)





**Figure A6.** A large, undercut scouring barrier to upstream fish passage located at UTM 11S 245261 E, 4264160 N, at the downstream end of Site ID 50102. (CDFW)





**Figure A7.** Cattle exclusion fencing running across the North Fork Stanislaus River, at the upstream end of Stanislaus Meadow (11S 244146 E, 4266217 N) on 4 August 2020.



**Figure A8.** Cattle exclusion fencing running across the North Fork Stanislaus River, at the downstream end of Stanislaus Meadow (11S 243940 E, 4264973 N) on 5 August 2020.